Heart Rate and Body Temperature Monitoring in Pair-Housed Mice Using Star-Oddi Micro-HRT Biologgers

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BACKGROUND

Chronic stress-related disorders (ie., PTSD) are associated with elevated cardiovascular disease (CVD) risk. Improved methods however are needed to examine longitudinal cardiovascular changes and physiological adaptations in chronic stress mouse models, taking into account group-housed settings that consider environmental and social factors.

To address this, we pilot tested the use of Star-Oddi micro-HRT biologgers for circadian and thermoregulatory monitoring of heart rate (HR) and body temperature (BT) in pair-housed mice during and after chronic stress exposure, combined with our custom software and video monitoring behavioral analysis system.

METHODS

Animals: Pair-housed C57BL/6 mice (10–12 weeks old, n=8).

Surgery: Micro-HRT biologgers were implanted subcutaneously on the back of each mouse.

Behavioral Paradigm: Chronic stress was induced using a Pavlovian fear conditioning paradigm, pairing a conditioned stimulus (CS; auditory cue) with an unconditioned stimulus (US, footshocks). Control mice received the CS alone.

Data recording: HR and BT were continuously recorded at 773 Hz for 7 days. Two variations of ECG amplification and bandwidth were tested. The quality of the recordings was assessed using raw ECG data and manual annotation, compared to on-board HR calculations and their associated quality index (QI) ranging from 0 (Best) to 3 (Worst). Amplification and bandwidth of the ECG signal was also assessed using power spectral density (PSD) analysis.
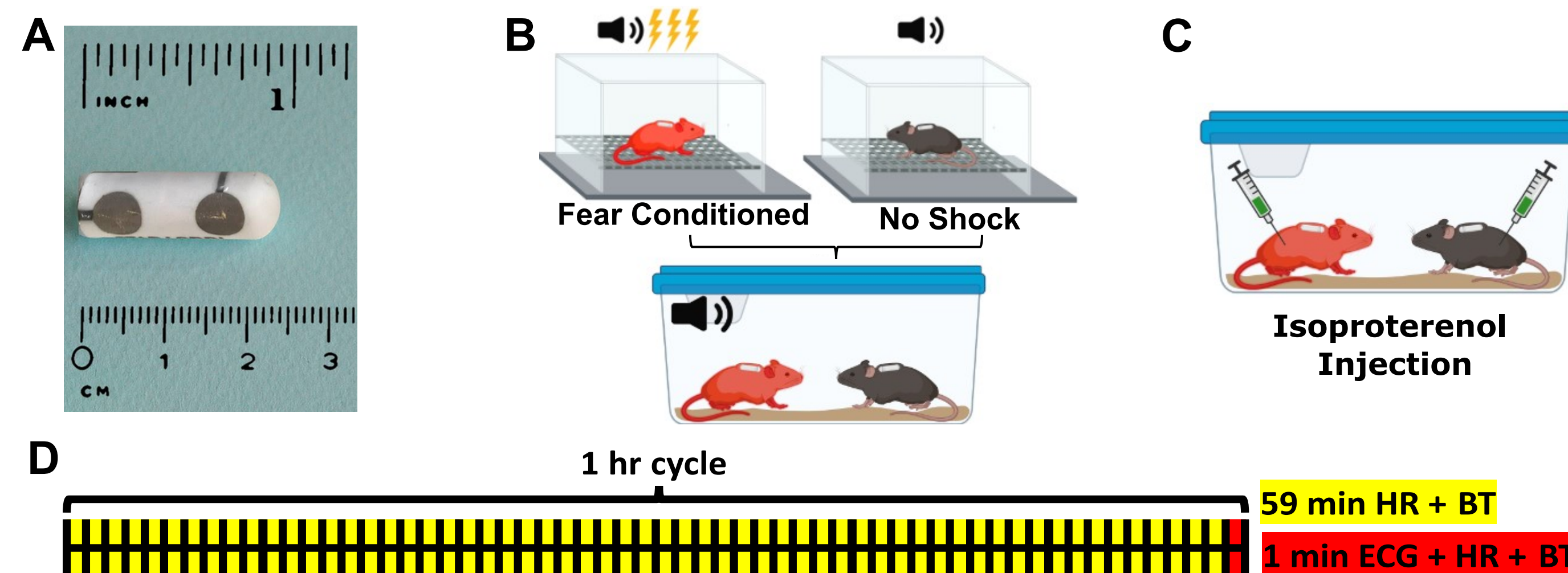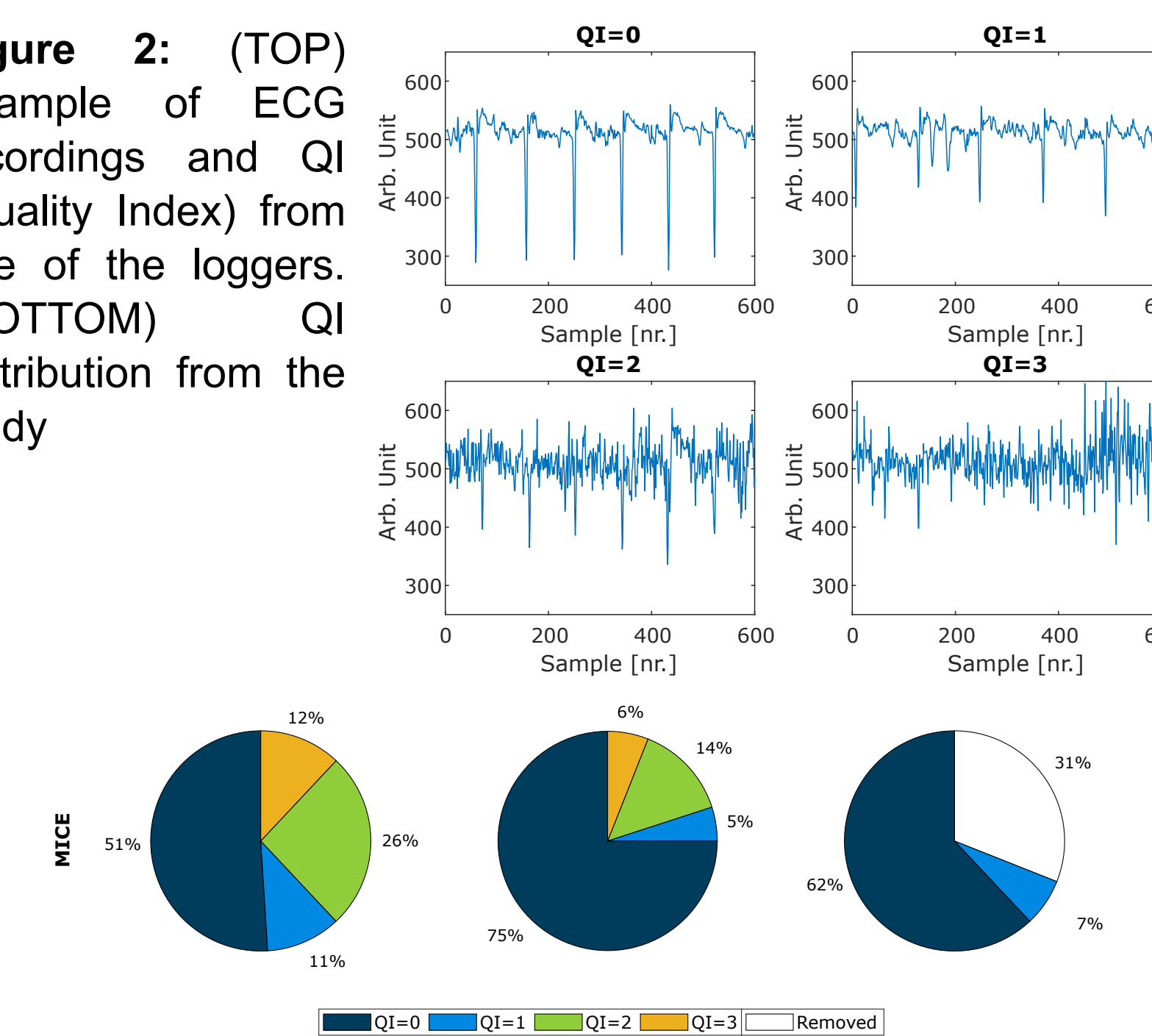

Figure 1: (A) DST micro-HRT (3.3g). (B) Chronic stress model. (C) Example of location of logger, group housed animals that received an Isoproterenol injection in the end of study to elicit maximum heart rate. (D) Logger recording cycle.

HEART RATE QUALITY

Both ECG bandwidth variations provided high-quality recordings, but the higher bandwidth setting yielded more consistent HR readings with a lower QI due to higher frequency content of the QRS waveform in mice. The on-board HR calculations correlated strongly with the raw ECG data, especially during rest, with a maximum HR of 804bpm, minimum HR of 329bpm and average HR of 548±105bpm. The subcutaneous body temperature had a maximum of 36.93°C, a minimum of 34.03°C and an average of 35.41±0.69°C.

Figure 2: (TOP) Example of ECG recordings and QI (Quality Index) from one of the loggers. (BOTTOM) QI distribution from the study

No significant difference was found between logger types, with average amplitude of the QRS waveform ranging from 13-20% FS. Power Spectral Density (PSD) estimation (Figure 3) revealed high variability between animals that warrants further investigation but also significantly higher frequency content then rats with peak content from 50-120Hz while rats are 20-60Hz.

Figure 3: Average Power Spectral Density (PSD) of the experiment with individual mice in multicolor. Signal is digitally bandpass filtered from 30-130Hz and compared to previously recorded data from rats.

RESULTS

CS-evoked changes in HR and BT tracked longitudinally stress-induced arousal states across day-night cycles (see Figure 4) showing both an acute but moderate increase in HR and BT. The stimuli was the strongest on Day 1 (see Figure 5), the Isoproterenol injection did elicit close to maximum HR response with average rates between 650-700bpm.
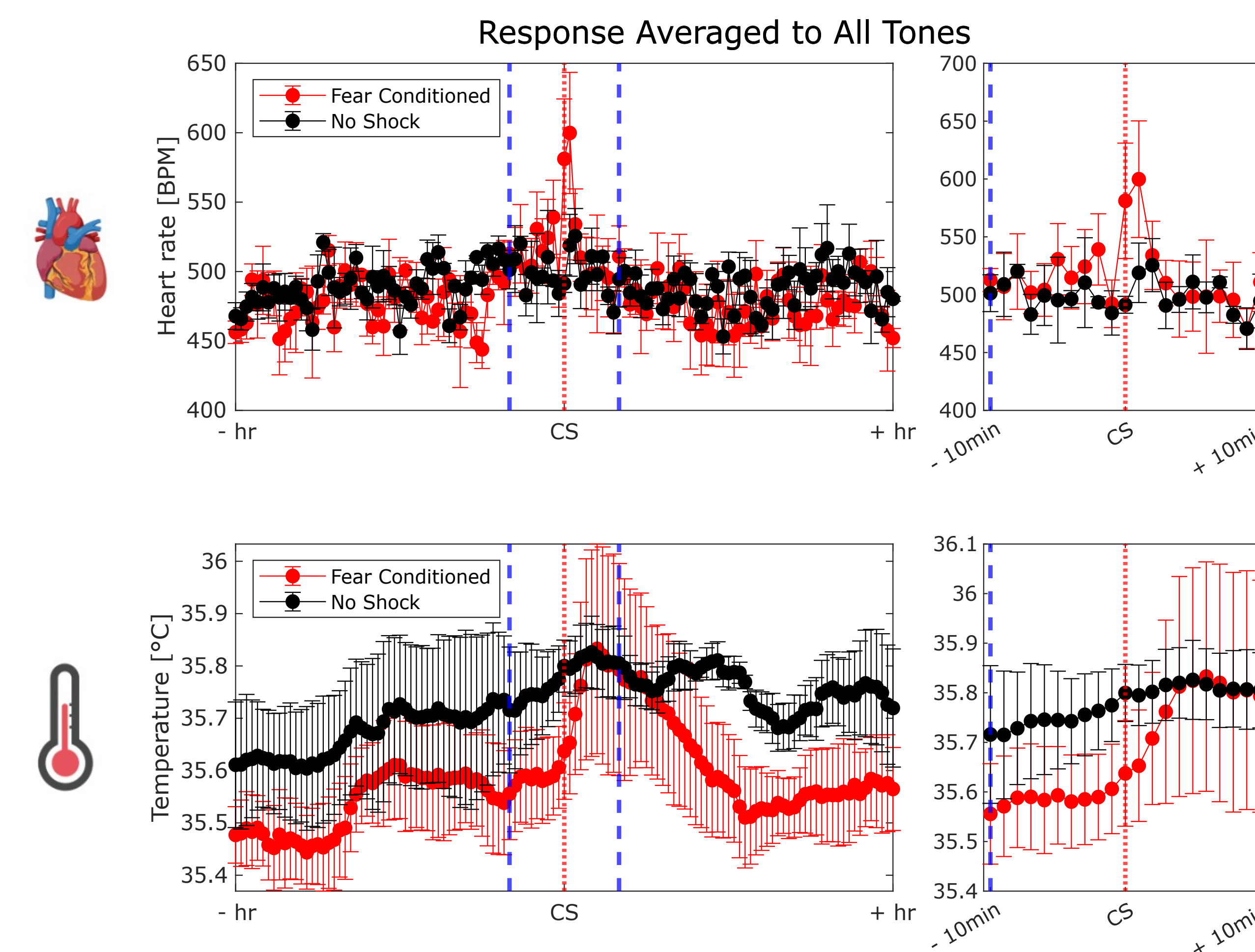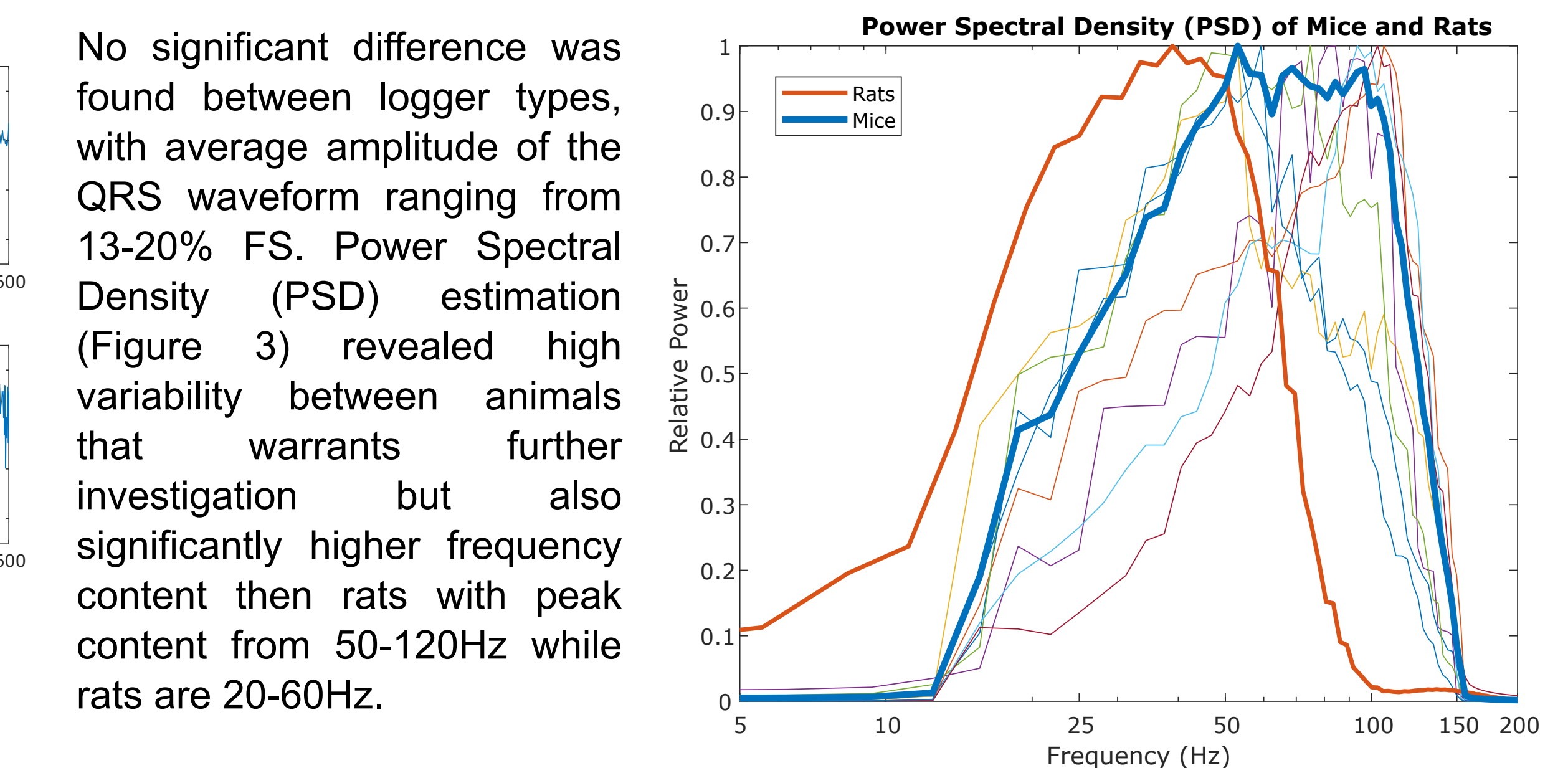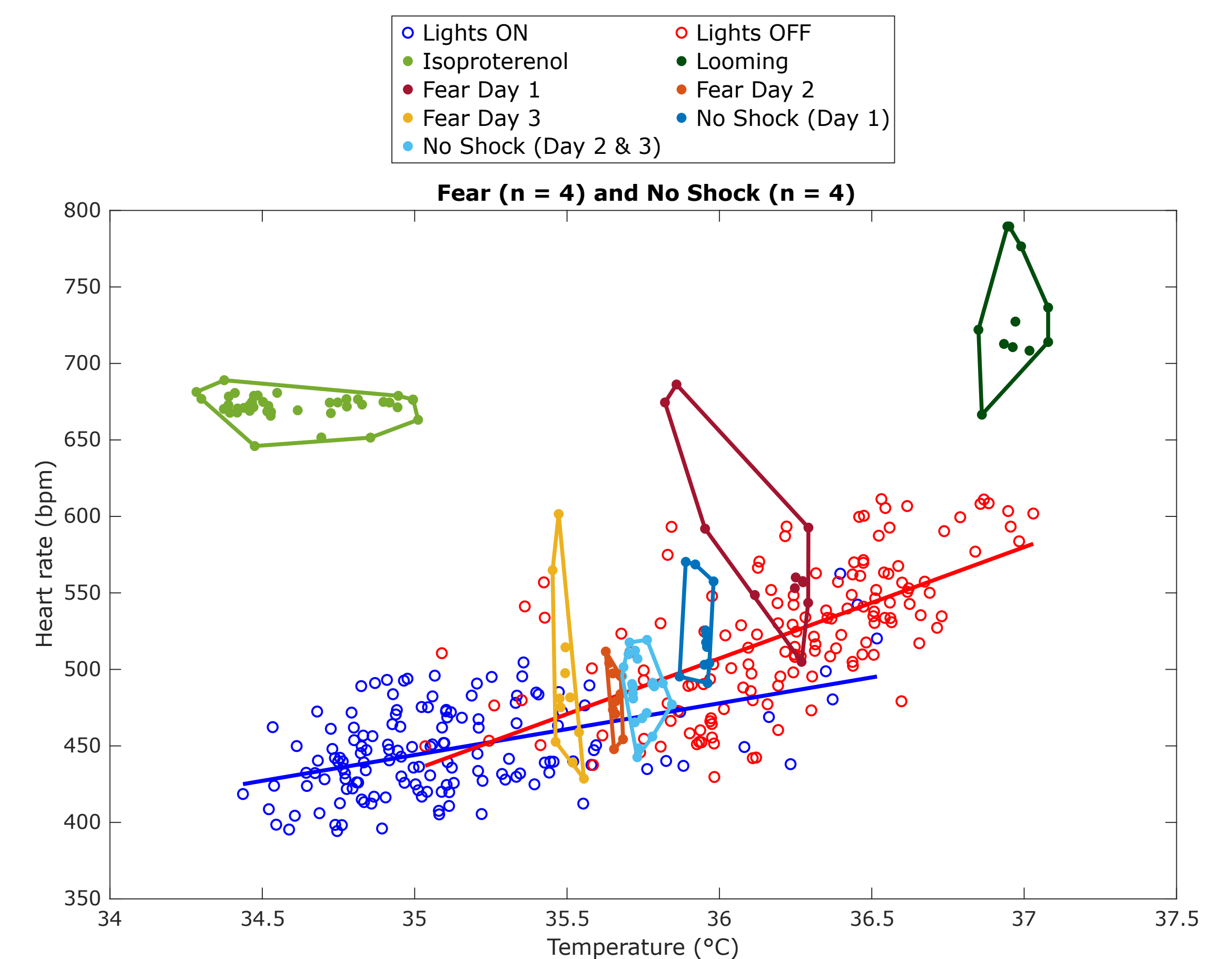

Figure 4: Physiological measurements from the average of 18 tones over three days in the two groups. Top graph shows HR and the bottom graph BT.

Figure 5: Relationship between 15min average HR and Temperature during lights off (red) and lights on (blue). In green is the minute group average of the Isoproterenol injection. Fear conditioned and No shock group averages are shown in different colors.

CONCLUSIONS

Star-Oddi micro-HRT biologgers effectively recorded normal longitudinal circadian patterns HR, ECG and BT, and corresponding stress-induced cardiovascular arousal states in pair-housed mice. This pilot study demonstrates the feasibility of using these biologgers for minimally invasive, high-resolution physiological monitoring in pair-housed mice, enabling the analysis of integrated circadian and stress-related cardiovascular outcomes.

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Citations: [1] Long term measurements of temperature, activity and heart rate in laboratory rats using data loggers as minimally invasive and low-cost screening too. Bjarnason A, Kreuser S, Cunio T, Bernal J. (2022) Society of Safety Pharmacology Annual Conference